Relationship between magnetic susceptibility and heavy metal content of soil

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Abstract
The magnetic susceptibility and the contamination level of soil have been showed a strong correlation since magnetic particle and contaminant are genetically related. The magnetic susceptibility, mineralogical composition and heavy metal content of 30 surface soil samples collected from uncontaminated forest, road side in industrial area and abandoned mine area were determined to examine their correlation. The soil samples from industrial and mine areas had a higher magnetic susceptibility and higher contents of heavy metal, magnetite and hematite comparing with the soil samples from uncontaminated forest. There was a strong correlation between the magnetic susceptibility and the content of Fe, Mn, Cr, Ni, Pb and Zn of the soils. They also showed a strong correlation with the content of Fe-oxide and Mn-oxide. The contents of As and Cu revealed a weak correlation with the magnetic susceptibility. However, they showed a strong correlation with the Fe oxide content. The correlation data indicate that the magnetic susceptibility measurement can be used as a screening tool of heavy metal level of soil.

Key Words
Magnetic susceptibility, magnetite, hematite, heavy metal.

Introduction
Magnetic susceptibility of a soil has been utilized in a variety of soil science researches such as soil genesis and morphology. Recently, the magnetic susceptibility has been adapted as a tool for the mapping of pollutant distribution (Wang and Qin 2005). The magnetic measurement is considered as a rapid and cheap screening tool for the determination of the spatial distribution of contamination level. The use of magnetic measurement as a proxy for chemical method is possible because pollutant and magnetic mineral are genetically related (Hanesch and Scholger 2002). Hematite and magnetite are common minerals and occur as primary and secondary minerals in soil and solid waste and provide a major sink for pollutants such as heavy metals in soils. They have been known as the major minerals contributing to the magnetic susceptibility of a soil. In addition to the presence of those minerals, the content of Fe, Mn, Cr, Co and Ni also affects the magnetic susceptibility of a soil. The magnetic susceptibility, the heavy metal content and the iron and manganese oxide content of 30 surface soil samples collected from forest, road side in industrial area and abandoned mine area were tested. We report the correlation between the magnetic susceptibility and heavy metal content of the soils.

Methods
Soil sampling and characterization
Thirty surface soil samples were collected from uncontaminated forest, road side in industrial area, and abandoned mine area. The collected soil samples were air-dried and gently ground with a rubber stoper to pass a 2 mm sieve. The samples with less than 2 mm in diameter were stored in a polyethylene bottle for further chemical and mineralogical analysis and magnetic measurement. The mineralogical composition of the samples was determined with an X-ray diffractometer. The metal contents were determined with the aqua regia extraction method. The Fe- and Mn-oxide contents were determined with the dithionite-citrate-bicarbonate method.

Measurement of magnetic susceptibility
The air-dried sample was filled in an acryl cube for the magnetic susceptibility measurement. The measurement was conducted with a magnetic susceptibility meter (MS2, Bartington Instruments Ltd., UK) at low and high fields.

Results

The soils collected from abandoned mine and industrial areas had a higher metal content and a higher magnetic susceptibility comparing with the soils collected from forest. There was little difference between magnetic susceptibilities measured at high field and low fields except one soil with high clay content. The soil containing a significant amount of magnetite and hematite had a relatively higher magnetic susceptibility ($1586 – 31963^{-10}$ SI) than the others ($76 – 1500^{-10}$ SI). The magnetic susceptibility showed a strong correlation with the contents of aqua regia extractable Fe, Mn, Cd, Cr, Pb, Ni, and Zn (Table 1). The content of aqua regia extractable As and Cu had a weak correlation with the magnetic susceptibility. The heavy metal content of the soil showed a strong correlation with the Fe-oxide content and/or Mn-oxide content. It implies that a significant portion of heavy metals in the soils occurs with Fe-oxide and/or Mn-oxide as adsorbed or coprecipitate form. The magnetic susceptibility data and the heavy metal contents of the soils from collected industrial area and abandoned mine area indicate that the magnetic measurement can be used as an indicator or a screening tool of metal contamination level of soil.

Table 1. Correlation coefficient (R^2) between the magnetic susceptibility measured at low field and the aqua regia extractable metal contents.

Metal	Fe	Mn	As	Cd	Cr	Cu	Pb	Ni	Zn
Correlation coefficient (R^2)	0.608	0.615	0.089	0.579	0.778	0.258	0.759	0.855	0.625

Conclusion

The combined data of magnetic and chemical measurements of the soils indicate that the magnetic susceptibility measurement can be a useful tool for the screening of contamination level.

References

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